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Chapter 1 – Making Buildings:

A/ Learning to Build: Often, the decision of which building materials to use is based on economics. But what costs less at first may cost more throughout its life cycle through maintenance and replacement, or energy use.

B/ Sustainability: Sustainability may be defined as meeting the needs of the present generation without compromising the ability of future generations to meet their needs.** According to the U.S. Green Building Council, buildings account for 30% to 40% of the world's energy use and associated greenhouse gas emissions.** Their rating system, **LEED** (Leadership in Energy and Environmental Design) has become the standard for measuring the sustainability of construction.**

C/ The Work of the Design Professional: Designers develop the building plan for effective design and to comply with the **legal constraints** like zoning ordinances and building codes along with any other constraints such as under the American Disabilities Act (ADA), the Fair Housing Act, EPA, OSHA, and other laws and rules.** Some of the sources of these legal constraints are:

Building Codes:
- International Residential Code (IRC) building code for 1 & 2 family dwellings, up to 3 stories**
- International Building Code (IBC) building code for all other buildings**
- National Electrical Code (NEC) – NFPA 70
- International Plumbing Code (IPC) or Uniform Plumbing Code (UPC)

Regulations:
- Zoning Ordinances – Through local municipal government, building permits control land use, limit the size, type, and density of the structure that may be built
- Environmental Regulations – Through the Environmental Protection Agency (EPA)
- Safety Regulations – Through the Occupational Safety and Health Administration (OSHA)

D/ Construction Standards and Information Resources:
- ASTM (American Society for Testing and Materials) establishes specifications for materials and methods.
- ANSI (American National Standards Institute) develops and certifies standards for construction products.
- CSI (Construction Specification Institute) developed a comprehensive outline called MasterFormat for organizing information about construction materials and systems. It is organized into 50 primary divisions.

E/ The Work of the Construction Professional: Constructing Buildings:
Construction Service Models:
- Design/Bid/Build – Owner separately hires design team and construction team.**
- Design/Build – Owner hires one entity that provides both design and construction services.
- Turnkey – Design/Build but includes financing.
- Single-Purpose Entity – Owner designs, constructs, and finances project.

Paying for Construction:

- Fixed fee (lump sum) – Owner pays general contractor an agreed, fixed amount for work performed.
- Cost plus a fee – Owner pays general contractor costs plus a fee.

Sequential versus Fast Track (Phased) Construction:

- In Sequential construction, each major phase in the design and construction of a building is completed before the next phase begins.
- Fast Track or Phased construction aims to reduce the time required to complete the project by overlapping the design and construction of various project parts.

Construction Scheduling:
Successful construction requires a detailed understanding of the tasks required and their interdependencies. Planning and scheduling involves analysis of these relationships between the different project activities using Gantt charts (bar charts) and Network Diagrams (flow charts) to understand which activities are bottlenecks to progress. These bottlenecks are considered critical activities. A critical path can be charted through the project where these critical activities are focused, to keep the project on schedule.

Additional Building Code Information (needed for exam):

Approval of Construction Documents: Approved plans and permit must be kept at the site of work. [IRC Ch#1 and IBC Ch#1]

Work Exempt from Permit: 1-story accessory structures ≤ 200sq. ft. (IRC) (≤ 120 sq. ft. for IBC); fences ≤ 7 ft. high; retaining walls ≤ 4 ft. from bottom of footing to top of wall; water tanks on grade ≤ 5000 gallons; sidewalks; driveways; finish work like painting, cabinets, countertops, or flooring; decks ≤ 200 sq. ft. and ≤ 30 in. above grade and not servicing required exit door (IRC). [IRC Ch#1 and IBC Ch #1]

Wind Design Criteria: In special wind hazard areas expecting over 110 mph, according to basic wind speed tables in the code, special design considerations are required. [IRC Ch#3 and IBC Ch#16]

Establishing the Design Flood Elevation: In flood hazard areas, determine design flood elevation. [IRC Ch#3 and IBC Ch#16]

Building Fire Prevention Location/Setbacks: For IRC, no openings in walls < 3 ft. to lot line, except for wall openings perpendicular to lot line; facing dwelling and structures on same lot; exempt accessory structures; foundation vents. Also openings are allowed up to 25% of wall area > 3 ft. but ≤ 5 ft. (unlimited if automatic sprinkler system present). Projections (eaves) a minimum of 5 ft. from lot line except for: 2 ft. okay if 1-hour fire protected on underside; 3 ft. okay if automatic sprinkler stems present; 4 ft. okay in detached garage if 2 ft. from lot line. IBC exceptions are more involved. [IRC Ch#3 and IBC Ch#7]

Chapter 2 – Foundations:

A/ Foundation Settlement:
When foundation settlement occurs at roughly the same rate throughout all portions of a building, it is termed "**uniform settlement**" (usually on uniform soil).** But when settlement occurs at differing rates between different portions of a building, it is termed "**differential settlement**" (usually on differing soil or with unequal building loads).** Foundations on **bedrock** settle a negligible amount whereas foundations on **clay or silt** can settle a great deal.**

Aggregates and Soils:

Aggregate Safety:

- **Silica Dust:** Silicon is the eight most common element, and the most common metalloid. Silica (silicone dioxide or SiO_2). Inhalation of crystalline silica dust leads to reduced lung capacity, and eventually silicosis, bronchitis, and lung cancer. You are exposed to this dust in sand, gravel, clay, and cement powder. Even sweeping a warehouse floor can become a serious exposure.
- **Weight:** Typical aggregates used in construction weigh about 105 pounds per cubic foot (ranging from about 90# to 120#).

Aggregate Definitions:

- Course Aggregates: (same as Gravel for most purposes) Aggregate that is **retained** on the **No. 4 sieve** (4.76-mm or about 3/16-in.) **
- Fine Aggregates: (same as Sand for most purposes) Aggregate that passes through the No. 4 sieve and is retained on the No. 200 sieve (74-microns)
- Bank Gravel: Gravel found in natural deposits, usually intermixed with fine material
- Crushed Gravel: Gravel created by artificial crushing – with at least **one face** resulting from fracturing **
- Crushed Stone: Stone created by artificial crushing – with all faces resulting from fracturing

Sources of Aggregates:
Sand and gravel banks occur from nature processes of parent rock broken mostly by temperature changes and transported and worn down by glaciers, gravity, wind, and water. There are two basic sources:

1/ Underwater Sources:

- Lake and river bottoms mined by barge-mounted dredges with single scoops or an endless chain of scoops, by a draglines, or by pumps similar to those used for pumping concrete
- Aggregate is then washed, crushed if necessary, then sorted with grates, screens/sieves.

2/ Land Sources:

- Glacier deposits, former lake and river beds, bases of rock faces, or blasted/excavated rock mined by bucket loaders, power shovels, draglines, or power scrapers (after stripping topsoil) **
- Aggregate is then washed, crushed if necessary, then sorted with grates, screens/sieves.

Properties of Aggregates:

- Properties/Qualities of aggregates:
- Weight (density)
- Resistance to Weathering (especially freezing/thawing)
- Compressive Strength, Tensile Strength, and Abrasive Resistance
- Adhesive and Cohesive (frictional)Qualities

- Permeability of the Mass (to allow water to flow through)

Aggregate Strength:
As a vertical load from the top is transmitted deeper, through points of contact, the load is spread over an ever larger area, with ever smaller forces at deeper levels:

- Well-graded aggregate is stronger than not well-graded aggregate.
- The larger the maximum size of aggregate is, the greater the strength. **
- The more flat, broken faces the particles have, the greater the strength developed through interlocking*
- Compaction, especially by vibration, increases the shearing strength of aggregate of any size, shape, and gradation. **
- Rough particle surfaces increase strength because of greater friction between them.

Definition: Compaction is the densification of a material resulting in an increase in weight per unit volume.

Bank, Swell, and Compaction/Shrinkage:

- Material in its natural state is referred to as ***bank*** material and is measured in **bank cubic yards (bcy)**.
- When bank material is excavated, the particles of earth are disturbed, and begin to swell. This expansion causes the soil to assume a larger volume; this expansion represents the amount of ***swell*** and is expressed as a percentage gained above the original volume. Uncompacted excavated material is referred to as **loose cubic yards (lcy)**.
- When loose material is placed and compacted (as fill) on a project, it will be compressed into a smaller volume than when it was loose. And with the exception of solid rock, it will occupy less volume than in its bank condition. This reduction in volume is referred to as ***shrinkage***. Shrinkage is expressed as a percentage of the undisturbed original (or bank) volume. Compacted material is referred to as compacted cubic yards (ccy).

So **bank**, **loose**, and **compacted** cubic yards are used to refer to what we are talking about:

- Compaction is the densification of a material resulting in an increase in weight per unit volume.
- Well graded aggregates compact more easily than poorly graded aggregates.
- Compaction generally increases strength of aggregates, reduces settlement, and improves bearing capacity. **
- In typical pavement construction, the load spreads over an area that increases with depth. Therefore, **the unit stress is less at greater depths**. The material is arranged to be weaker and less expensive at greater depths. **

Aggregate Volume Questions:

1/ Basic Volume of Earth Calculation:

Given a 20,000 sq. ft. plot of land, how many cubic yards would be required to cover this plot with 4-inches of river-silt? **

20,000 sq. ft. x 4-inches/12-inches = 6666.66 cu. ft.

6666.66 cu. ft./27 cu. ft. = 246.9 cu. yd.

2/ Swell (and Haul) Volume Calculation:

If 1000 bank cubic yards (in place at natural density) of dense clay (30% swell) needs to be hauled away, how many loose cubic yards would have to be hauled away by truck?**

Cubic yards of haul = In-place quantity x (1 + swell percentage)

Therefore: cu yds of haul (lcy) = 1000 bcy x (1 + 0.3) = 1300 lcy

Also: If 7 cy dump trucks will be used to haul this material away, how many loads would be required?**

Loads = lcy of haul / lcy per load

Therefore: Loads = 1300 lcy / 7 lcy per load = 186 loads

3/ Shrinkage (and Haul) Volume Calculation:
If 500 compacted cubic yards in-place of sand/gravel is required, how many loads would be required? Then material has a swell of 15% and shrinkage or 95%.**

Required bcy = Required in-place cy/Shrinkage

Therefore: Required bcy = 500 in-place ccy/0.95 = 526 bcy

The volume of material to be transported is calculated as follows:**

Loose cubic yards = Bank cubic yards x (1 + Swell)

Therefore: lcy = 526 bcy x (1 + 0.15) = 605 lcy

Also: If the same 7 cy dump truck is used, the following would be the number of loads required:**

Loads = 605 lcy/7 lcy per load = 86 loads

Roadbeds and Asphalt:

Asphalt Safety:

- Heat: Hot asphalt can easily be several hundred degrees, so it can cause severe burns to the skin
- Flammability: Cutback liquid asphalt contains flammable solvents that can cause fires and explosions.

Bituminous Materials:

- Tar: Tar is generally produced as a byproduct during the production of coke (not the drink). It is not very soluble in carbon disulfide (or most petroleum products). Tar has little bitumen content (a type of hydrocarbon).**
- Asphalt: Petroleum Asphalt is the basic paving material (used along with aggregates). It is a cementitious material, solid or semisolid, with large bitumen content** so it is quite soluble in carbon disulfide (and many other petroleum products).

Asphalt Production:

- Asphalt Cements: Asphalt is produced from crude oil by fractional distillation.** The oil is heated, the lighter oils vaporize, and are drawn off, leaving a residual material—asphalt cement.
- Liquid Asphalts: To eliminate the need for heating asphalt to a liquid state, asphalt is modified into two different liquid forms (Asphalt Cutbacks and Asphalt Emulsions):**

  - Asphalt Cutbacks: Produced by dissolving the cement into a solvent. They are classified as Rapid Curing (RC), Medium Curing (MC), and Slow Curing (SC), with a viscosity rating in "centistokes" where a higher number is more viscous.
  - Asphalt Emulsions: Produced by separating the hot cement into tiny globules and dispersing them in water that has been treated with an emulsifying agent.

Asphalt Testing (of Asphalt Cements):

Generally, tests performed on asphalt will measure consistency, durability, rate of hardening, serviceability, and the ability to be effective in hostile environments (like Louisiana). Asphalt is a thermoplastic material that changes viscosity with changes in temperature, so these tests are set at specific temperatures.**

Some of the tests performed: the penetration test, the viscosity test, the flash-point test, the thin-film oven test, the ductility test, and the solubility test.

Asphalt Pavements:

The basic idea in building a road for all-weather use by vehicles is to prepare a suitable sub-grade or foundation, provide necessary drainage, and construct a pavement that will do the following:

- Have sufficient strength to carry expected loads.
- Prevent moisture from penetrating or accumulating internally.
- Have a surface that is smooth and resistant to wear, distortion, skidding, and deterioration.

The Many Pavement Layers:** (from bottom to top)

1st: The **Sub-Grade** ultimately carries all traffic loads, so it must be prepared and structurally sound.
2nd: A **Sub-Base** of better quality aggregate is often layered on top of the sub-grade.
3rd: Then a **Base Layer** is placed on top of these layers made of a well-graded limestone road-building aggregate mix, or an asphalt-aggregate mix, or even portland cement concrete.
4th: Finally, an **Asphalt Surface** (asphalt-aggregate mix) is laid on top of all of these layers.

Determining Required Pavement Thickness:

There is no standard thickness for pavement. However, common thicknesses range from **1" for driveways to 10" for highways**** over well prepared and structurally sound bases. Some factors that are considered:**

- Traffic Analysis: The weight and volume of traffic that a road will carry influences the required thickness.
- Sub-grade Evaluation: Through testing and soil analysis, the strength of the sub-grade influences the required thickness.
- Asphalt Paving-Mix Design: The quality of the asphalt paving mix design influences the required thickness.

Types of Asphalt Pavement Construction:

- Plant Mix: The Asphalt Cement and Aggregate are heated separately from 250°F to 325°F in a plant**, mixed together and hauled to the jobsite, spread and compacted by rollers before it cools. It is called Hot Mix Asphalt (or HMA).
- Road Mix (Mixed-in-Place): Often used for lower layers, Liquid Asphalt (either Cutback or Emulsion) is mixed or sprayed on-site, eliminating the need for a central mixing plant. A Road Mix is NOT heated.**
- Slurry Seal: A thin asphalt overlay applied by a continuous process machine over worn pavement to seal them and provide a new wearing surface.

- Asphalt Spray Applications: Prime Coats and Tack Coats are used to bond asphalt layers other layers or to base materials.**

Estimating Asphalt Concrete:
The unit of measure for the purchase of asphalt concrete is the ton (2000#). Each cubic foot of asphalt concrete weighs about 150#, so when you calculate the volume of material needed, you can then figure out how many tons needed, using this fact (150# = 1 cu. ft.):

Asphalt Mix Volume/Weight Calculation:
Calculate the tons of asphalt concrete needed to pave an area of 180,000 sq. ft. at 3-in thick if the weight per cu. ft. is 150#:**
1/ Convert 3-inches into feet: 3-in x 1-ft/12-in = 0.25 feet

2/ Calculate the volume: 180,000 sq ft x 0.25 ft = 45,000 cu ft

3/ Convert volume to pounds: 45,000 cu ft x 150#/cu ft = 6,750,000#

4/ Convert pounds to tons: 6,759,000# x ton/2000# = 3375 tons

Other Uses of Asphalt:
Because of the preservative and waterproof characteristics of asphalt, it is used in many roofing products, in pipe coatings, in automotive under-coatings, in slope stabilizing mulch treatments, and in joint materials used to fill joints and crack in pavements and other structures.**

B/ Excavation:

Two basic methods to prevent collapse — (1) Excavation **Shoring**, and (2) Excavation **Sloping**

Shoring (or Slope Support Systems): The two most common types of shoring or slope support are **soldier beams and lagging**, and sheet piling: ** (see below)

1/ **Soldier Beams and Lagging**: Steel columns called H-piles or soldier beams are driven vertically into the earth at small intervals (12-feet) around an excavation before excavation begins. As earth is then excavated, the lagging (usually heavy wood planks) is placed inside the flanges of the columns. This is really just a special type of sheet piling.

2/ **Sheet Piling**: Vertical planks of wood, steel, or precast concrete are placed tightly against one another, and driven into the earth to form a solid wall before excavation begins.

Shotcrete: Shotcrete is pneumatically applied (air pressure) zero-slump concrete from a hose onto the steep slope to stabilize and prevent erosion.

Slurry Walls: Slurry walls are more complicated and expensive to construct, but are effective with **deep foundations**.** First, concrete guide rails are installed to guide the excavation. Second, the trench is dug, using a special clamshell bucket, between the guide rails, while filling the hole with a bentonite clay slurry, to keep the excavation walls from collapsing. A welded cage of rebar is lowered into the slurry, and then concrete is pumped into the trench from bottom to top while the slurry is pumped from the trench at the top. This wall is tied back into the earth behind for support.

Soil Mixing is a technique of adding a modifying substance to soil and blending it in place (in the ground) by means of augers or paddles rotating on the end of a vertical shaft.

Bracing:
All forms of slope support must be braced against soil and water pressures as the excavation deepens. Here are **three methods**:**

1/ **Crosslot Bracing:** Temporary columns are driven into the earth to support horizontal bracing that goes across the **excavation** from one vertical sheeting wall to the other. Crosslot Bracing is not practical in large excavations, or where the bracing is in the way of construction.

2/ **Rakers:** Sloping rakers are also external braces that brace at angles down from the vertical sheeting wall to the ground. Rakers also can get in the way of construction.

3/ **Tiebacks:** Tieback are internal braces that are embedded into the earth behind the vertical sheeting wall. Holes are drilled through the wall into the earth behind. Steel cables or tendons are then inserted, and grouted to anchor them. Then these tiebacks are post-tensioned before attaching them to walers on the wall.

Dewatering: Most excavations require some sort of dewatering or extraction of water. **Well Points** employ sump pumps to artificially lower the water table surrounding the excavation.** Another system, a Watertight Barrier, works like a pool liner in reverse, if the bottom edges are inserted into an impermeable layer.

C/ Foundations (Deep Foundations):

1/ **Caissons** or drilled piers are large heavy duty column footings with diameters ranging from 18-inches up to 8-feet.** Belled caissons are created with a special belling bucket that excavates the bottom of the caisson much wider to spread the foundation weight over a larger area.

2/ **Socketed Caissons** are drilled into rock at the bottom rather than belled.

3/ **End Bearing Piles** are driven until they reach bedrock or other suitable bearing stratum, to support structures.

4/ **Friction Piles** are used (in deep foundations) to drive into softer soil, where bedrock is too far down to reach (say, 300 ft).** They rely on increased friction as the pile extensions are added and by clustering a group of these piles (2 to 25) that are capped with a pile cap. Friction piles are very common in southern Louisiana.

Base Isolators: In areas **like Southern California**, where strong earthquakes are common, buildings are sometimes place on **base isolators**.** When significant ground movement occurs, the base isolators flex or yield to absorb s significant portion of this movement.

D/ **Underpinning**

Underpinning is the process of strengthening and stabilizing the foundations of an **existing building**.** Three types of underpinning:
1/ A new foundation wall and footing constructed **beneath** the existing foundation
2/ New piles or caissons constructed **on either side** of the existing foundation
3/ Mini-piles inserted **through** the existing foundation

E/ Retaining Walls:

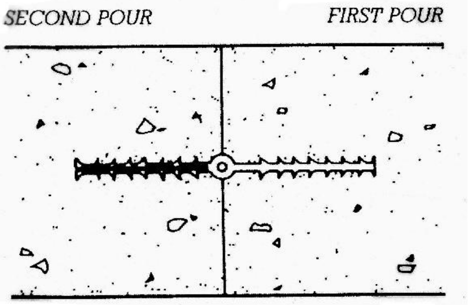
A retaining wall holds soil back to create an abrupt change in elevation of the ground. A retaining wall must resist the pressure of the earth that bears against it on the uphill side.

Earth reinforcing, with Geotextiles/synthetic mesh layered into the soil, can be an **economical alternative** to constructing conventional concrete retaining walls.**

F/ Waterproofing and Drainage:

Drainage Mats are used in place of drain rock drainage backfill (placed vertically) behind a foundation wall to relieve water pressure.** A drainage mat is a manufactured component that may be made of a loose mat of stiff, inert fibers, a plastic egg-crate structure, or some other very open, porous material. It is faced on the outside with a filter fabric that prevents fine soil particles from entering and clogging the mat's drain passages.

Synthetic Rubber Waterstop is used to seal against water penetration at movement joints between pours of concrete in a foundation.** (See sketch above)



Plan view (from above) of foundation wall.

G/ Calculating Volumes for Excavation and Concrete:

Volumes are determined by multiplying three dimensions that are perpendicular to each other, using a common unit of measure. Whether you define the dimensions as length, width, height, depth, or thickness is not important, but you must use the same units of measure (feet, for example) for each dimension as you multiply. Concrete and aggregates are bought and sold by the cubic yard. A cubic yard is equivalent to 27 cubic feet, so when you calculate a volume in cubic feet (as is usually the practical units to use), you must divide the cubic feet by 27 cubic feet, to find the number of cubic yards.

Additional Building Code Information (needed for exam):

Soils, Grading, and Drainage: Grading from foundation shall fall at least 6 in. within the first 10 ft. except for when lot lines or walls prevent this and drains or swales are used. Impervious/hardscape (like driveway) within 10 ft. of building shall be sloped at least 2% grade away from building. [IRC Ch#4 & IBC Ch#18]

Shallow Foundations: Exterior walls must be supported by foundations that can support the loads, built on undisturbed soil, compacted fill material, or controlled low-strength material, with excavation free of organic material. Footings must be at least 12 in. below undisturbed ground surface (or more depending on variables such as required frost protection). Footing width must be at least 12 in. (or more, depending on variables such as building loads). [IRC Ch#4 and IBC Ch#18]

Concrete Monolithic Slab with Footing: 3½ in. minimum thick slab; thickened slab perimeter footing width must be at least 12 in. (or more, depending on building loads); Minimum 6 mil polyethylene vapor retarder over free draining soil. Slab must have at least 6 in. above grade and at least 12 in. below undisturbed ground surface (or more depending on required frost protection). [IRC Ch#4&5 and IBC Ch#18]

Pier Foundations: The sizing of an isolated footing for a column load is based on tributary load (expected maximum live and dead loads) compared to the assumed load-bearing capacity. [IRC Ch#4 and IBC Ch#18]

For example, if the total expected building load on the column is 13,000 pounds, and the assumed load-bearing capacity of the soil is 1500 psf (pounds per square foot), then you can calculate the size of the pad footing required:

13,500 pounds/1500 psf = 9 sq. ft.

Therefore, you need a pad footing with 9 sq. ft. bearing on the soil, or a 3 ft. x 3 ft. pad.

Concrete Basement Foundations: No backfilling more than 4 ft of basement wall until walls are anchored to completed floor diagram. Treat exterior wall with damp-proofing (or waterproofing) before installing drainage system (drain-tile and drain-rock) and backfilling behind foundation wall. [IRC Ch#4 and IBC Ch#18]

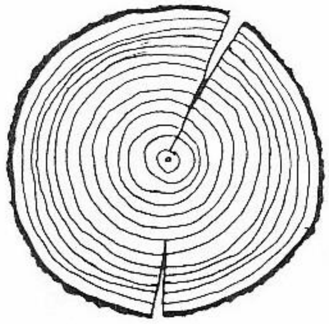
Chapter 3 – Wood:

A/ The Growth of Trees: Softwood comes from evergreen conifers such as pine, fir, spruce, and cedar. Hardwood comes from deciduous broadleaf trees such as oak, cherry, maple, and poplar. Not all softwood is softer than all hardwood.** The darker lines in the growth rings of a tree (called "Summerwood") represent slower growth and are heavier, harder, and stronger wood than the lighter wood (called "Springwood") that grows much faster in the spring. Wood grown in dry climates is more dense and stronger than wood grown in moist climates.** The direction of the long axis of wood cells is referred to as the direction of the grain.

B/ Moisture and Shrinkage: The moisture content in wood is expressed as a percentage of the weight of the oven-dry wood. The m. c. of wood does not exceed 19% in normal outdoor usage. Wood can shrink up to 10% across the grain (transverse shrinkage) but shrinks very little along the grain (longitudinal shrinkage).**

Seasoning: Seasoning (drying) is the process of wood reaching moisture equilibrium with its surrounding atmosphere. Seasoning can be achieved by natural drying (up to a four year process), or by using a kiln (for hours or days), sometimes with **hygroscopic chemicals** added to reduce shrinkage cracks.** The label "**S-Dry**" means the lumber was surface after drying (and implies a moisture content ≤ 19%).** The label "**S-Grn**" means the lumber was surface while still green. The label "MC15" states that the lumber was seasoned to a moisture content of 15%. Lumber used for framing must always be below MC19, and lumber used for molding and trim should be below 11%.

Shrinkage along the length of the log (**longitudinal shrinkage**) is quite small. Shrinkage across the diameter of the log (**radial shrinkage**) is quite large. Shrinkage around the circumference of the log (**tangential shrinkage** –see sketch ->) is about as great as radial shrinkage. Cracks or checks that come from the center of the tree to the outside (like you might search for when splitting wood) result from tangential shrinkage.**



Lumber: When wood is cut into pieces of specific thickness, width, and length, it is called lumber. It is divided into boards, dimension lumber, and timbers. Plain-sawn lumber is cut parallel with the growth rings to show an open or flat-grain appearance. Quarter-sawn lumber is cut perpendicular with the growth rings to show a close or vertical grain appearance. Plain-sawn lumber is often acceptable for common framing members and other hidden uses. Quarter-sawn lumber is more often chosen for furniture and flooring, and has less trouble with distortions.** Wood is not used in great quantities in commercial construction because of fire regulations.**

Dimension lumber used in framing is generally made from softwood, and often interior trim and furniture is made from hardwood. Lumber with its smallest dimension greater than 5½" is called timber.** The table below shows the differences between the nominal sizes and the actual sizes of dimension lumber also with board-foot equivalence:

Nominal Size….	….Actual Size	Board Feet per linear foot	Nominal Size….	….Actual Size	Board Feet per linear foot
1 **x 2**	¾ x 1 ½	1/6 BF	2 x 2	1 ½ x 1 ½	1/3 BF
1 x 4	¾ x 3 ½	1/3 BF	2 x 4	1 ½ x 3 ½	2/3 BF**
1 x 6	¾ x 5 ½	**1/2 BF****	2 x 6	1 ½ x 5 ½	**1 BF****
1 x 8	¾ x 7 ¼	2/3 BF	2 x 8	1 ½ x 7 ¼	1 1/3 BF
1 x 10	¾ x 9 ¼	5/6 BF	2 x 10	1 ½ x 9 ¼	1 2/3 BF
1 x 12	¾ x 11 ¼	**1 BF****	2 x 12	1 ½ x 11 ¼	**2 BF****

Board-Feet: Lumber is often sold by the board-foot (BF). One board-foot is a 12-inch by 12-inch piece of wood that is one-inch thick. As with the dimension lumber table above, you always round up to the nearest whole inch for thickness and width. Even a ¼-inch piece of hardwood flooring is rounded up to one-inch when calculating board-feet.

Looking at the table above, notice that one linear foot of 1 x 12 = 1 BF, and one linear foot of 2 x 6 = 1 BF. One board-foot has a nominal cross-sectional area of 12-square inches by one foot long. So the formula for calculating board-feet using the rounded up dimensions: (THICKNESS in inches X WIDTH in inches / 12) X LINEAR FEET = BOARD-FEET

For example: Calculate the number of board-feet in 32 @ 2x4s which are 12-feet long:**
⇨ 2" x 4" = 8 sq in Therefore: 8sq in/12 sq in = 2/3 bf

Multiply this unit board-feet by the linear feet: 2/3 bf x 32 @ 12-foot ea = 2/3 bf x 384-feet = 256 bf
OR…just use the formula: (2" x 4" / 12") x 384 linear ft = 256 bf

C/ Wood Products:

Engineered Lumber (also called Structural Composite Lumber):** Many forms of engineered lumber and panels have become available because of the shortage of quality large trees and because of better glues and manufacturing techniques. They are generally more dimensionally stable and often stronger than solid wood. Five general classifications of engineered lumber: Glulam (Glue-Laminated Lumber), LVL (Laminated Veneer Lumber), PSL (Parallel Strand Lumber), LSL (Laminated Strand Lumber), and Wood I-Beams.

Glulams: Glue laminated lumber, or Glulams are made from lengths of solid, kiln-dried lumber that have been glued together. They are popular in architectural applications where exposed beams are used, or where a specific curved shape is needed. They can be made to any size (and in fact have been made up to 500' long) and are stronger than solid timbers. Individual laminations (individual board pieces) are commonly 1½" thick and the end joints between them are either finger jointed or scarf jointed for a stronger connection (more surface area) between pieces.

PSLs (Parallel Strand Lumber): PSL (brand name: **Parallam**) is made from long strands of wood that are bonded together with adhesive and heat. PSL is the heaviest and most expensive of the engineered lumber. They come in 3 ½" and 7" thicknesses, up to 24" depth, and up to 60' long.

LVLs (Laminated Veneer Lumber): Like plywood, LVL (brand name: **Microllam**) is made from laminated wood veneer, except that the grain of each layer runs in the same direction as the other layers. LVL is stronger than PSL or LSL.** They come in 1 ¾" and 3 ½" thicknesses, range from 9" to 24" depth, and up to 60' long.

LSLs (Laminated Strand Lumber): Like OSB sheathing, LSL (brand name: **Timber-Strand**) is made from lumber strands. LSL is used for short span headers, and in millwork such as doors and windows.

Of all the engineered lumber, Glulam Beams can span the greater distance/handle the greater loads. PSLs are second, spanning a greater distance than LVLs only because they are available in greater thicknesses.** LSLs are not used for significant spans. Wood I-Beams can span significant distances with smaller loads, as long as they are well braced, but they don't hold up well in fires…they burn fast!**

D/ Plastic Lumber: Lumber-like products with a plastic content of 50 percent or more are referred to as plastic lumber. Commonly manufactured for exterior decking, and fencing, decay and maintenance is not a problem. Plastic lumber does have problems with strength/span, U/V deterioration, expansion/contraction, and flammability.

E/ Wood Panel Products:

Structural Wood panels, typically 4' x 8', are easier to install than solid wood boards. They also make more efficient use of forest resources, are more equal in strength in their principle directions, have less trouble with shrinkage, expansion, splitting, and distortion than solid wood boards.

Plywood: Plywood is made of layers of veneer lumber arranged with the grain at right angles in each successive layer and bonded with an adhesive. The panels are usually 4'x8' ranging from 1/8" to over 1". The adhesive used to make interior plywood is not very water-resistant, whereas the adhesive used in exterior grade plywood is fairly waterproof.** Plywood is graded by the quality of the layers of veneer from "A" (best) to "D" (worst). A-C plywood, for example, has an "A" veneer on the front surface and a "C" veneer on the back surface. The number of veneer layers is always an odd number so that the front and back layers run the same direction which gives the plywood greater strength along the direction of these layers.

OSB (Oriented Strand Board) is a strong, stiff (engineered) panel manufactured in a cross-ply pattern similar to plywood. The layers are formed from thin rectangular shaped wood strands oriented in layers at right angles to each other and bonded with waterproof resin adhesives. OSB is popular as wall and roof sheathing.

F/ Wood Chemical Treatments:

Wood is impregnated under pressure with Fire-retardant treatment (FRT) to reduce combustibility, and with preservatives to prevent decay. Two common methods of preserving wood from decay:

- **Creosote**: Creosote is an oily derivative of coal that is used in railway ties and train trestles. It is not paintable, and has an annoying odor, is toxic, and causes chemical burns to skin.
- **Salt**: The most widely used preservatives in building construction are **waterborne salts**, which permits painting and staining.** Chromated copper arsenate (CCA), alkaline copper quat (ACQ), copper boron azoles (CBA) are all rely on copper as the preservative. Borate compounds such as sodium borate (SBX) are the least toxic to humans, but are also not as effective as a preservative.

G/ Wood Fasteners:

Fasteners: Wood is fastened together with nails, screws, bolts, metal brackets/plates, and adhesives. When using any fastener for exterior applications, durability and corrosion resistance are critical. A bright nail has no real protection. A hot-dipped galvanized coating is better than electro-plated galvanize coating. Stainless steel is best, but more expensive. Decking screws are available with a protective paint coating. Screws have up to four-times the holding power of a comparable nail.** Metal brackets (made of galvanized sheet metal) such as joist hangers and hurricane straps are increasingly required for more reliable connections in tension and shear.

H/ Manufactured Wood Components:

Trusses:

Wood I-Joists: Wood I-Beams or Wood I-Joists (brand name: Trus-Joist or TJI) consist of a web (made of OSB or plywood) bonded to top and bottom flanges (made of lumber, LVL, or PSL). They are very light-weight members that are often used as floor or ceiling joists and rafters and are available up to 16" depth and up to 60' long. But they are **less fire resistant** than conventional solid wood.

Panel Components: These are prefabricated wood panels. A Framed Panel is identical to a segment of a conventionally framed wall, floor or roof. A Stressed-Skin Panel (SSP) has a panel on both sides of a frame where the facings are bonded with adhesive. A Structural Insulated Panel (SIP) sandwiches insulating foam between two wood panels (usually OSB).

Factory-Built Housing: Besides the infamous modular home (mobile home), less famous manufactured homes are built unit sections, no wider than 16-feet for transportation on roadways, and installed on site-made foundations. The efficiency of factory production make this form of construction very competitive. But residential design is a very traditional art, where unusual construction does not hold value well.

I/ Types of Wood Construction:

- Heavy Timber Framing (Chapter 4)
- Wood Light Frame Construction (Chapter 5)

(End of Guide)